The Economics of Adolescent Meningococcal Vaccination in the US:

Direct and Indirect Benefits

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Objective

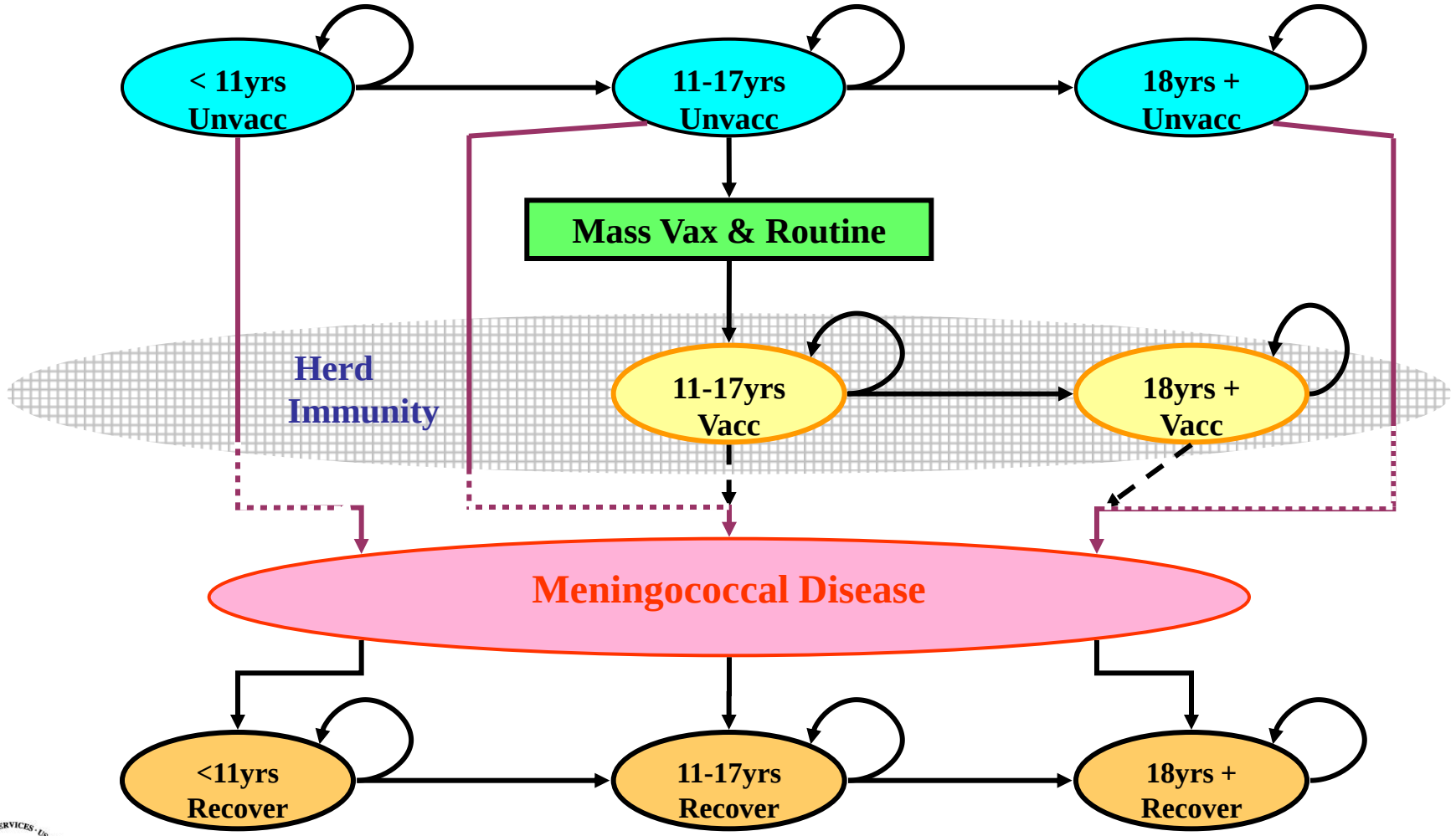
- Analyze the effectiveness and cost-effectiveness of a mass meningococcal vaccination program (MCV4) in **11-17 yrs** adolescents in the US

- Evaluate the individual (*direct*) and potential herd immunity (*indirect*) impacts of an adolescent vaccination program in all the population

Design

- Monte Carlo simulation analysis
- Hypothetical population
  - One million 11-17 years old cohort within a 10 Million US age-representative population sample.
- Strategy
  - One time mass vaccination in 11-17yrs + routine vaccination of each new 11 years old cohort
- Time Frame: 10 years
- Analytic Horizon: Age-specific Life Expectancy
- Discount rate: 3% (0%-5%)

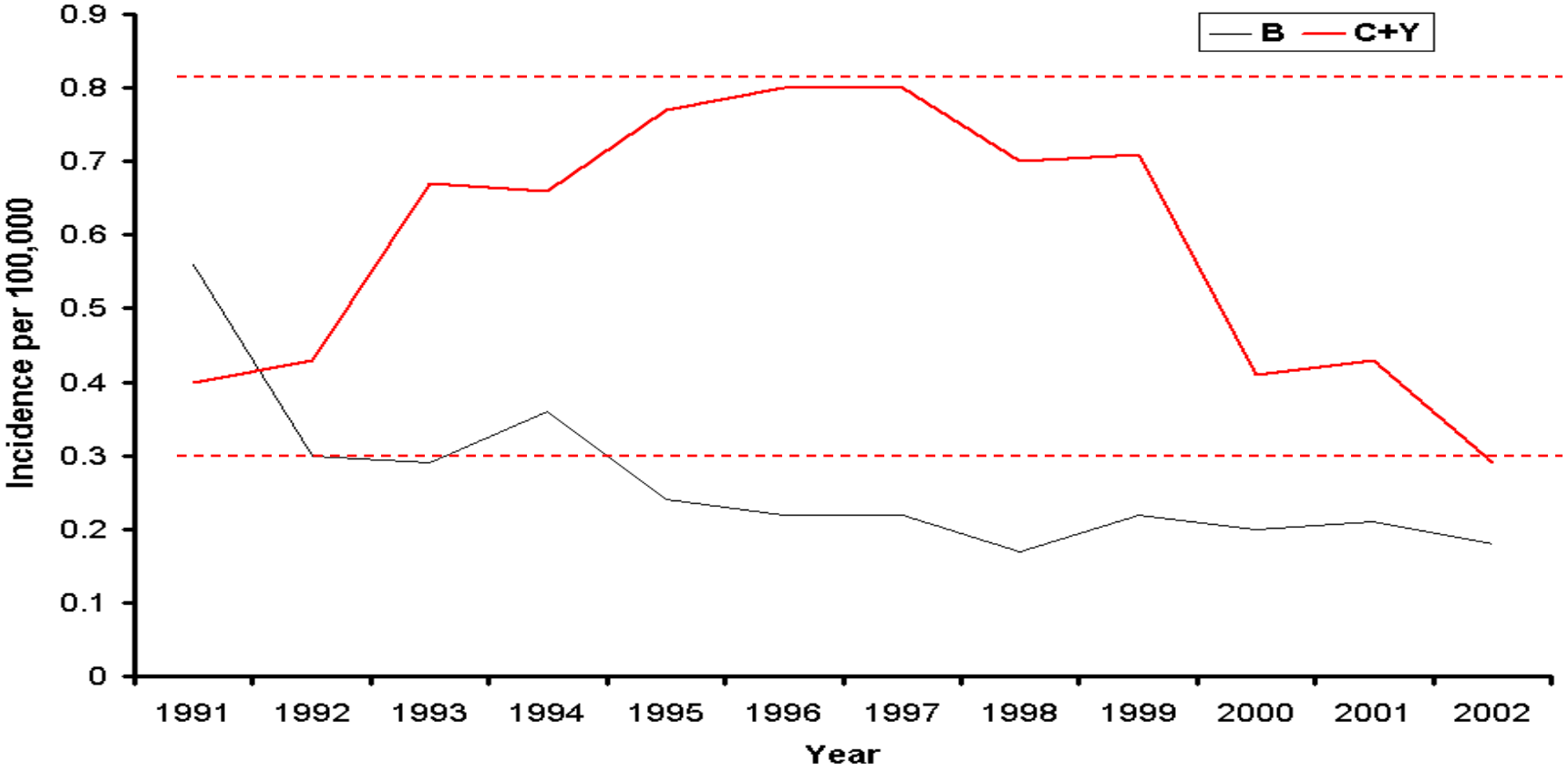
The Model


< 11yrs Unvacc
11-17yrs Unvacc
18yrs + Unvacc
Mass Vax & Routine
Herd Immunity
11-17yrs Vacc
18yrs + Vacc
Meningococcal Disease
<11yrs Recover
11-17yrs Recover
18yrs + Recover

Epidemiologic Data

- Age- year- and C+Y+W135 serogroup-specific incidence rates (1991-2002)
- Age- and serogroup-specific case fatality ratios
- Proportion of survivors with sequelae by condition
- Vaccine efficacy: 93% (39-99%) from MCC campaign in UK
- Duration of vaccine efficacy: 10 years
- Age-specific herd immunity impact: UK experience
- Coverage in adolescents: 70% (16-95%)
  - **Shepard et al., Pediatrics 2005**

Annual Incidence of C+Y and B Serogroups: per 100,000*



* Active Bacterial Core Surveillance

Case Fatality Ratio: Age and Serogroup Specific (ABC data)*

Age group	Proportion of Deaths by MCV4 Serogroups				Case Fatality Ratio **	
	C	Y	W135	All MCV4	C+Y+W135	All serogroups
<1 yrs	47	0	0	47	0.02	0.05
1 yrs	67	0	0	67	0.02	0.03
2-4 yrs	82	9	0	91	0.06	0.06
5-10 yrs	50	20	0	70	0.05	0.06
11-17 yrs	47	38	0	84	0.11	0.13
18-22 yrs	58	10	0	68	0.09	0.14
23-32 yrs	35	35	10	80	0.10	0.12
33-64 yrs	31	37	7	75	0.12	0.16
65+ yrs	14	48	2	64	0.12	0.19
Overall	**37**	**31**	**3**	**72**	**0.08**	**0.10**

* **Active Bacterial Core Surveillance, 1993-2002**

Proportion of Survivor Cases with Sequelae by Type of Condition

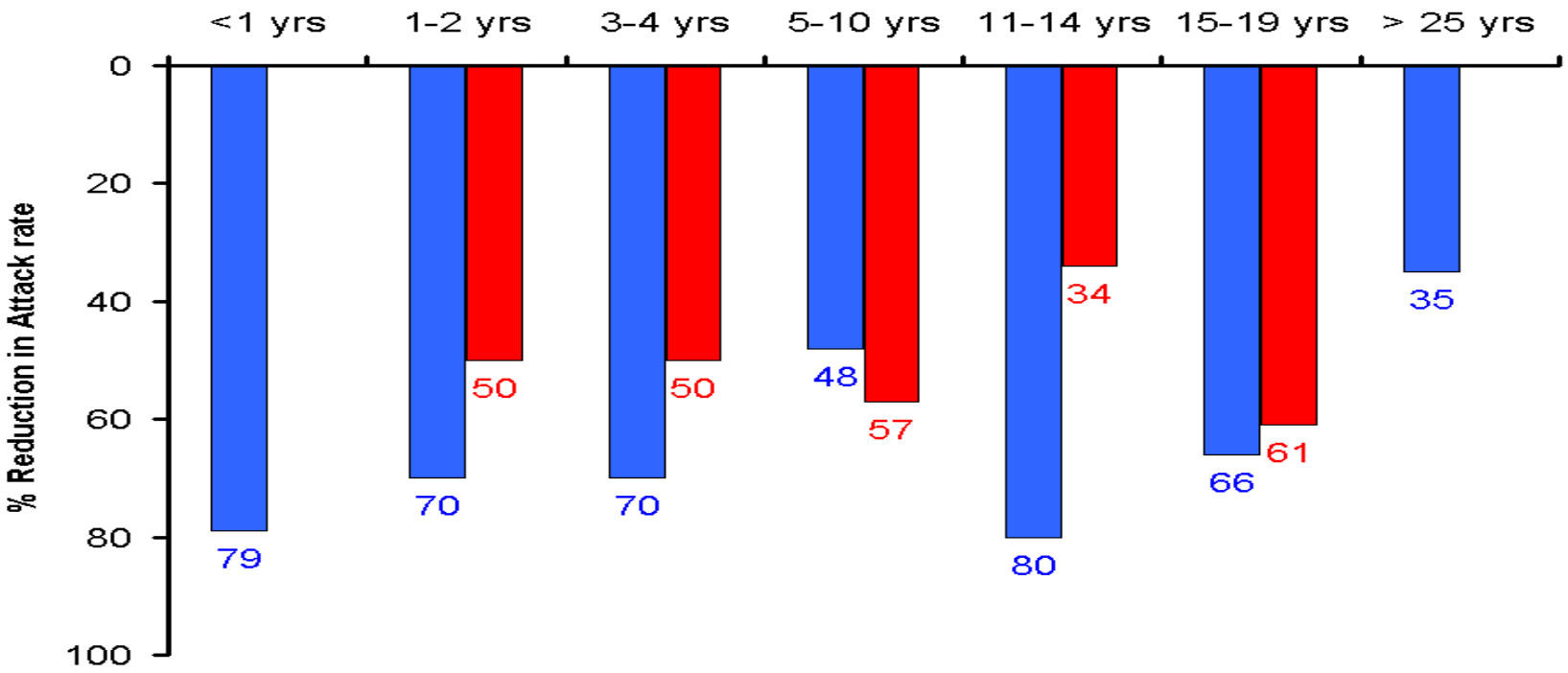
Skin scarring	7.6	(0-19)
Single amputation	1.9	(0.5-10)
Multiple amputations	1.2	(0.02-6)
Hearing loss*	8.8	(2-20)
Significant long term neurologic disability**	2.1	(0.02-11)

* Edwards *et al*. Complications and sequelae of meningococcal infections in children. J Pediatrics 1981; 99:540-5

** Baraff *et al*. Outcomes of Bacterial meningitis in children: a meta-analysis PIDJ 1993;12:389-94

Percentage Reduction in Attack Rate in Unvaccinated Cohorts After MCC Campaign in UK

Herd immunity impact was chosen *randomly* from the following two studies:



Ramsay *et al.*, BMJ, 2003: 326:365-366

Balmer *et al.*, J. Medical Microbiology, 2002: 51:717-722

Cost of Illness*

	Total Costs Acute Infection	% indirect costs as time from work loss
Per case	$ 34,590	4.9%
Complication	+ Long term costs	+ lifetime prod.
Death	$ 1,340,348	97.4%
Skin scarring	$ 40,288	4.2%
Single amputation	$ 200,906	37.3%
Multiple amputations	$ 453,860	48.8%
Hearing loss	$ 344,889	70.6%
Neurologic disability	$ 3,127,925	23.5%

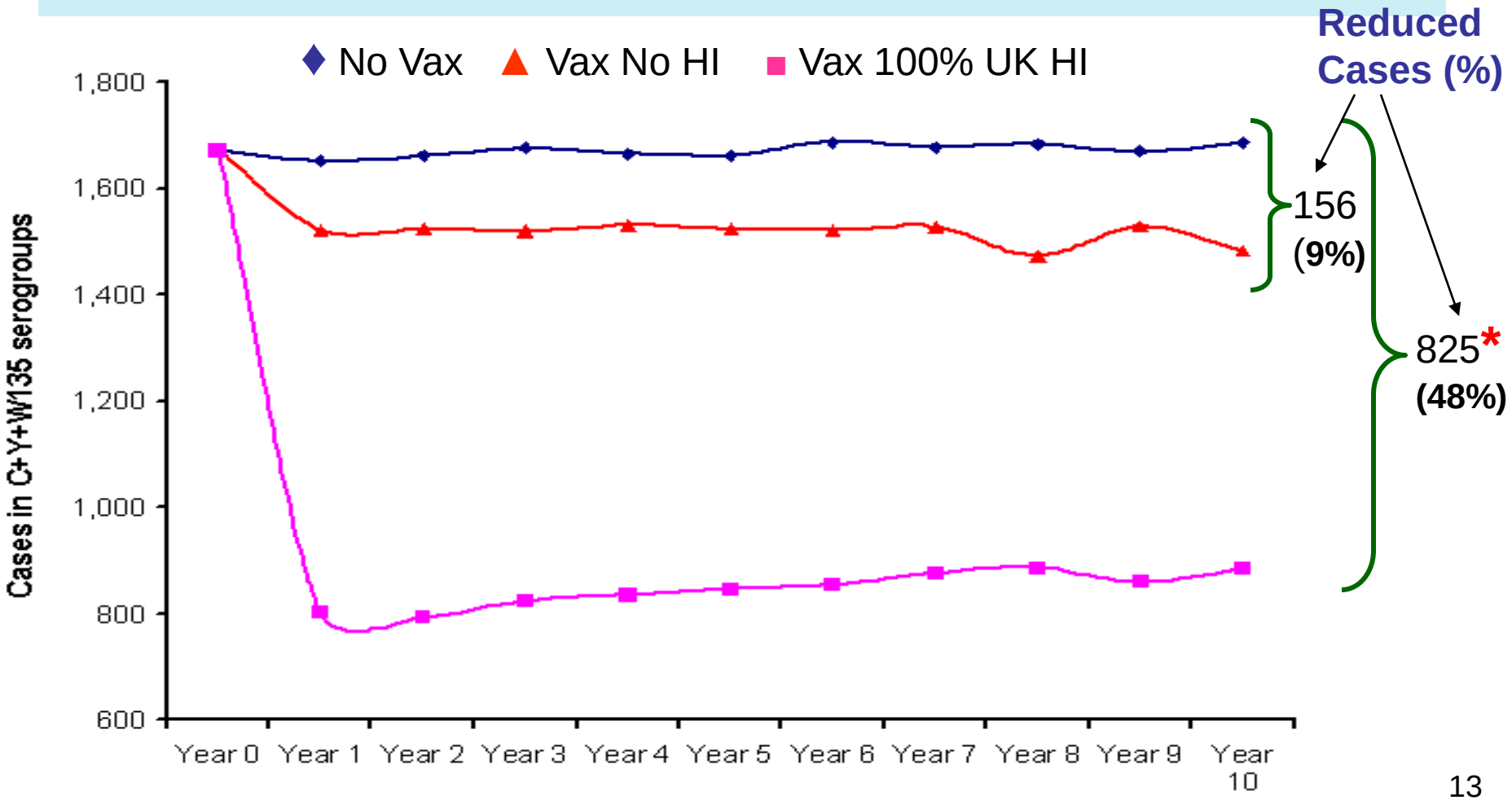
* Cost measured in 2003-2004 in **Shepard *et al*., Pediatrics, May 2005,** were updated to **December 2006 US$**

Cost of Vaccination

- Cost components of vaccination program
  - Vaccine
    - Public and private sector prices
    - 2006 price of meningococcal conjugate vaccine
    - Wastage 10.7% (range 0-25%)
  - Administration fees
  - Adverse events
- Estimate of cost per vaccination
  - $83 Base case, (range $64-$114)

Results

Annual Number of Cases in the US Attributable to C+Y+W135 Serogroups With and Without Mass Vax in 11-17yrs (Two Herd Immunity Scenarios)



*Assumes Herd Immunity impact equivalent to the reported in UK, 93% vaccine efficacy and 70% coverage in 11-17yrs

Cumulative Number of Health Outcomes Prevented in 10 years for the US*

	No vaccination	Mass vax & routine	Outcomes prevented
All acute cases	16,706	8,455	8,251
All complications	3,608	1,826	1,782
Deaths	1,489	781	698
Life-years lost	69,180	32,349	36,831
Life-years lost (discounted)	30,548	15,087	15,264
QALYs lost	127,572	58,188	69,383
QALYs lost (discounted)	53,051	25,521	27,150

* Assumes 70% vaccine coverage in 11-17 yrs and 100% UK HI

Costs of Disease, Vaccination and Health Outcome in 10 years for the US*

	No vaccination	With mass vax & routine	Cost (savings)
Total disease cost	**2,852**	**1,381**	**(1,471.2)**
Direct costs	1,071	520	(551.1)
Indirect cost	1,781	861	(920.1)
Vaccination program costs **	**n/a**	**3,268**	**3,267.8**
Net cost *			
Payer	n/a	n/a	2,716.7
Societal	n/a	n/a	1,796.6
Cost per case / case prevented **			
Payer	0.064	0.335	n/a
Societal	0.171	0.223	n/a
Cost per life lost / life saved **			
Payer	0.719	3.943	n/a
Societal	1.916	2.623	n/a

* In Millions 2006 US$. Costs are discounted at 3%

** Cost per vaccinee $83

Cost-effectiveness Comparisons of MCV4 Interventions*

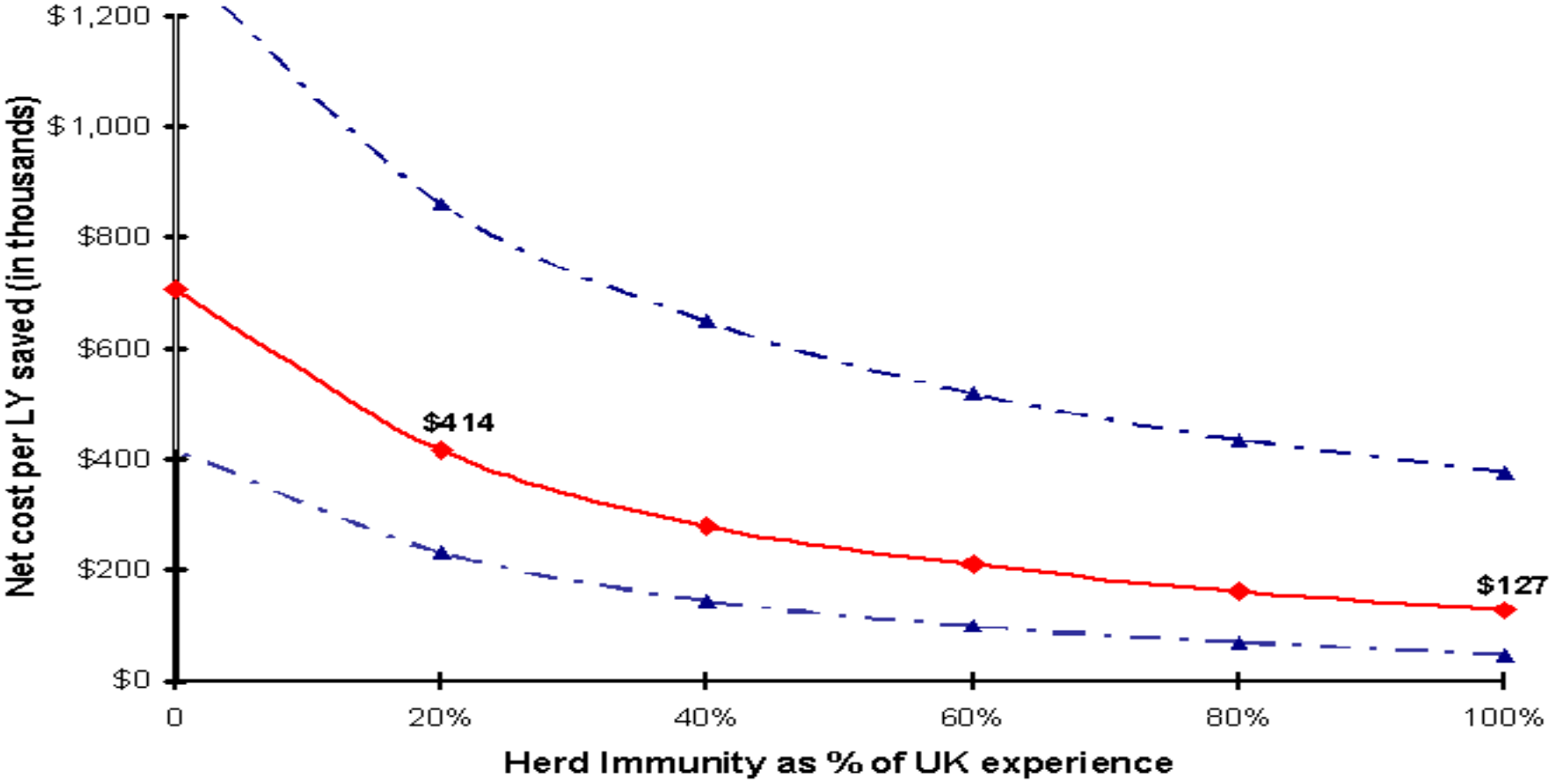
	Herd Immunity	Cost per Life-year Saved		Societal Cost per QALY saved	Source
		Payer	Societal		
Mass vax and routine (Ramsay rates) **	Yes	136,000	116,000	81,000	Current analysis
Routine 11-year olds (20y efficacy)	No		121,000	118,000	Shepard 2005
**Mass vax and routine ** **	**Yes**	**147,000**	**127,000**	**88,000**	**Base-case**
Routine toddlers (20y efficacy)	No		166,000	105,000	Shepard 2005
Routine 11-year-olds (10y efficacy)	No	219,000	205,000	179,000	Shepard 2005
Routine infants (<1y) (20y efficacy)	No		482,000	271,000	Shepard 2005

* Cost were updated to 2006 US$ and rounded to the nearest thousand

** Assumes 100% UK Herd Immunity

Net Cost per LY Saved* Under Different Herd Immunity Scenarios: Median, 5% and 95%

(Mass Vax 11-17 yrs.+ Routine in 11 yrs)



* No valuation of productivity lost due to premature death
Assumes 70% of vaccination coverage in 11-17yrs & $83 vaccination cost

Cost-effectiveness Comparisons of MCV4 with Other Vaccines*

	Herd Immunity	Cost per Life-year Saved Societal	Source
Pertussis routine in all 11- to 18-year-olds	Yes	6,300	Caro 2005
HPV routine in females 12y +	Yes	18,000	Taira 2004
Mass vax and routine (Ramsay rates) **	Yes	116,000	Current analysis
**Mass vax and routine ** **	**Yes**	**127,000**	**Base-case**
1st year college students in dorms with MPV4	No	297,000	Scott 2002
Meningitis prevented in infants with PCV-7	No	316,000	Lieu 2000

* Cost were updated to 2006 US$ and rounded to the nearest thousand

** Assumes 100% UK Herd Immunity

Strengths and Limitations

Strengths

- Complex modeling with direct and indirect effects of vaccination
- Explicit use of incidence and CFR surveillance data for MCV4 vaccine-containing serogroups

Limitations

- Data on vaccine efficacy and herd immunity are from the impact of MCC in the UK
- Quality of Life during the acute disease not assessed

Conclusions

- A one time mass vaccination of all healthy adolescents followed by a routine program in preadolescents could have substantial impact on burden of disease
  - up to 48% reduction in cases
  - 80% of prevented cases are from herd immunity
- For the same duration of vaccine efficacy, catch-up and routine could be as half expensive per LY saved or QALY saved as routine vaccination of 11-12 years old only.

Collaborators*
(in alphabetical order)

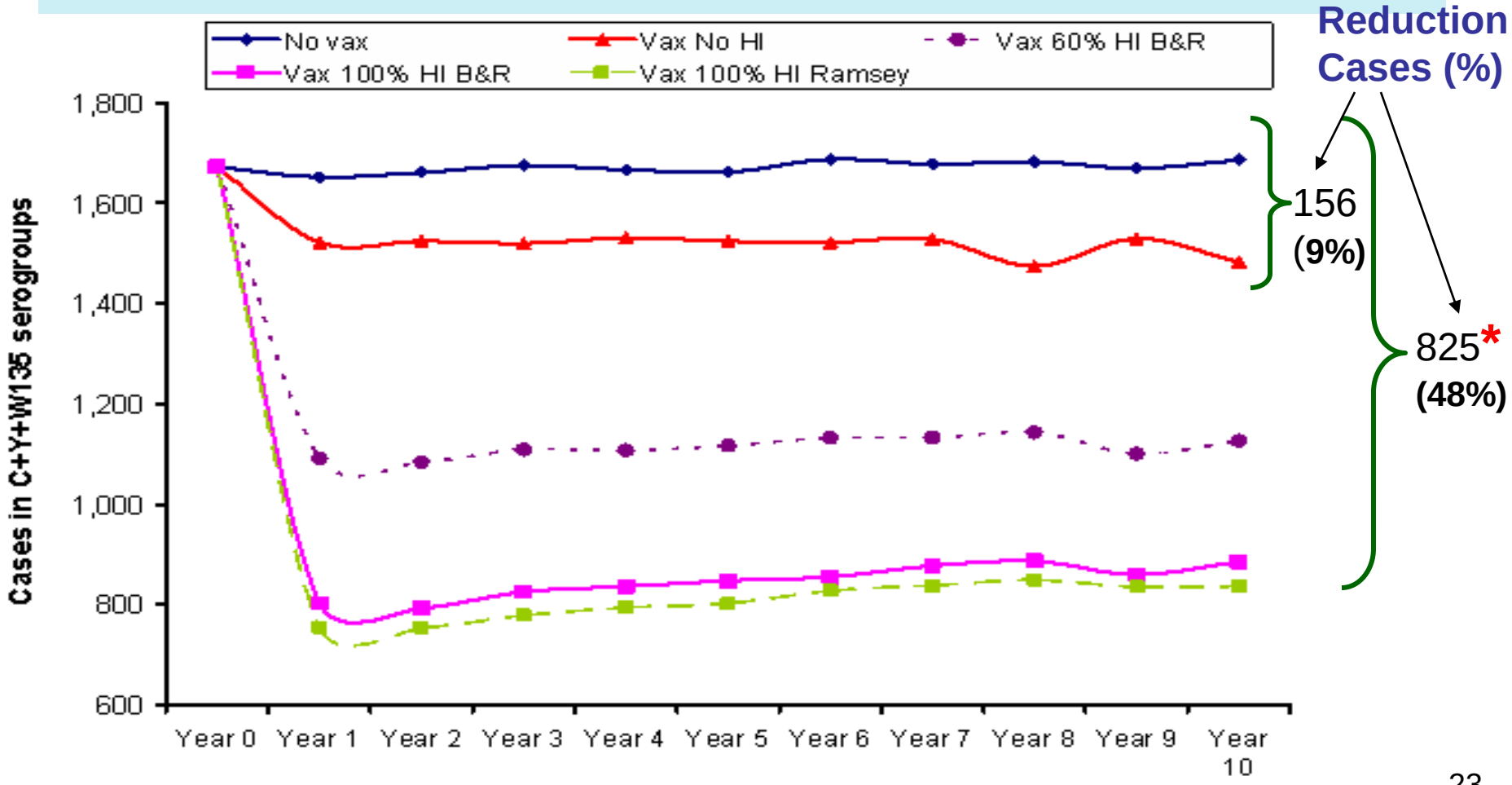
- Oleg Bilukha, was with NCID
- Martin I. Meltzer, NCPDCID
- Nancy Messonnier, NCIRD
- Mark L. Messonnier, NCIRD
- Colin Shepard, was with NCID
- David S. Stephens, Emory University
- Elizabeth Zell, NCIRD
- Xinzhi Zhang, was with NCID

ABCs surveillance team

* All collaborators, no conflict of interest

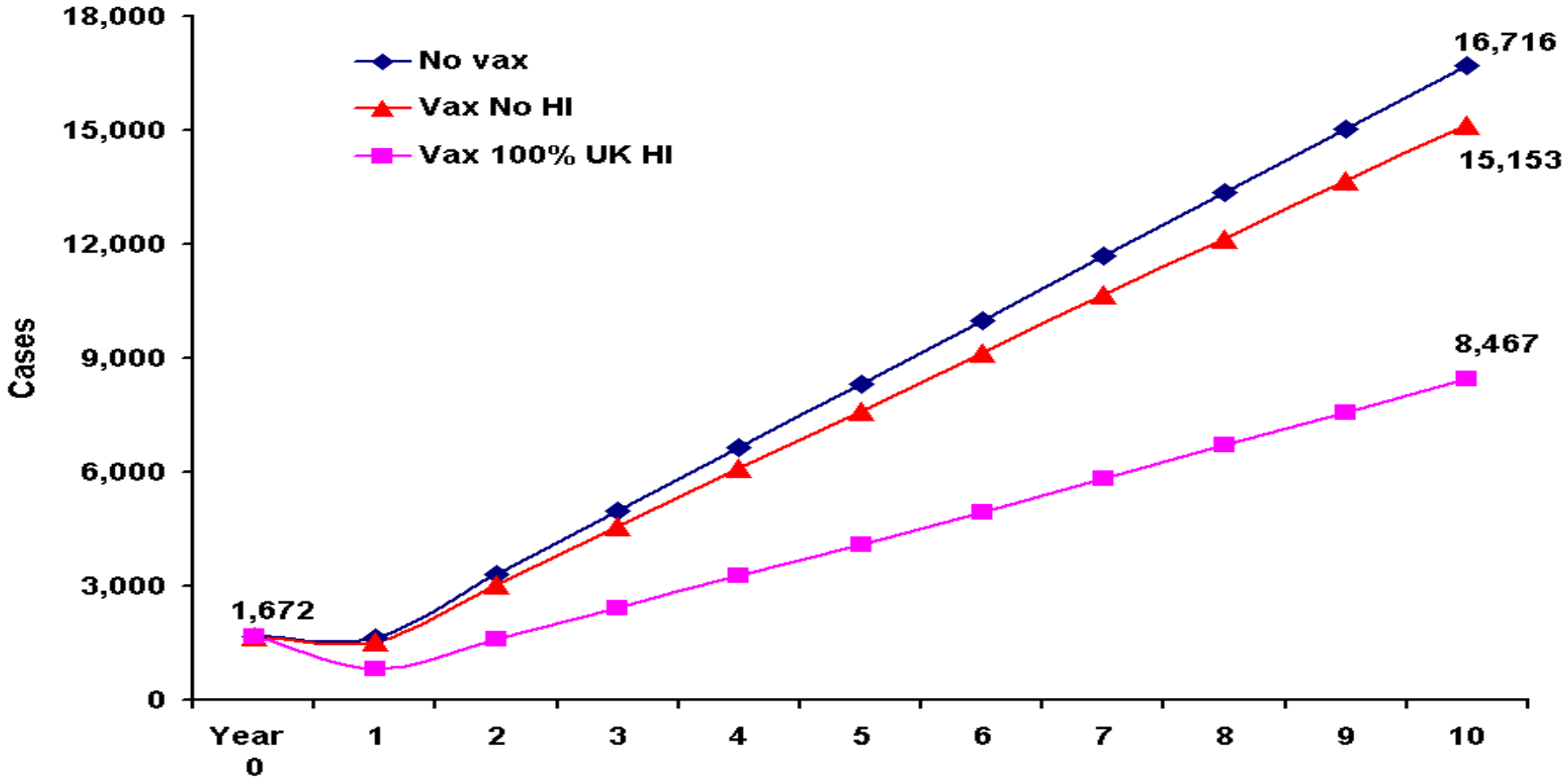
Appendix

Annual Number of Cases in the US Attributable to C+Y+W135 Serogroups With Mass Vax in 11-17yrs (Four Herd Immunity Scenarios)



*Assumes Herd Immunity impact equivalent to the reported in UK, 93% vaccine efficacy and 70% coverage in 11-17yrs

Cumulative Number of C/Y/W-135 Cases and Cases Prevented in the US* in 10 Years (Median values from the Monte Carlo)



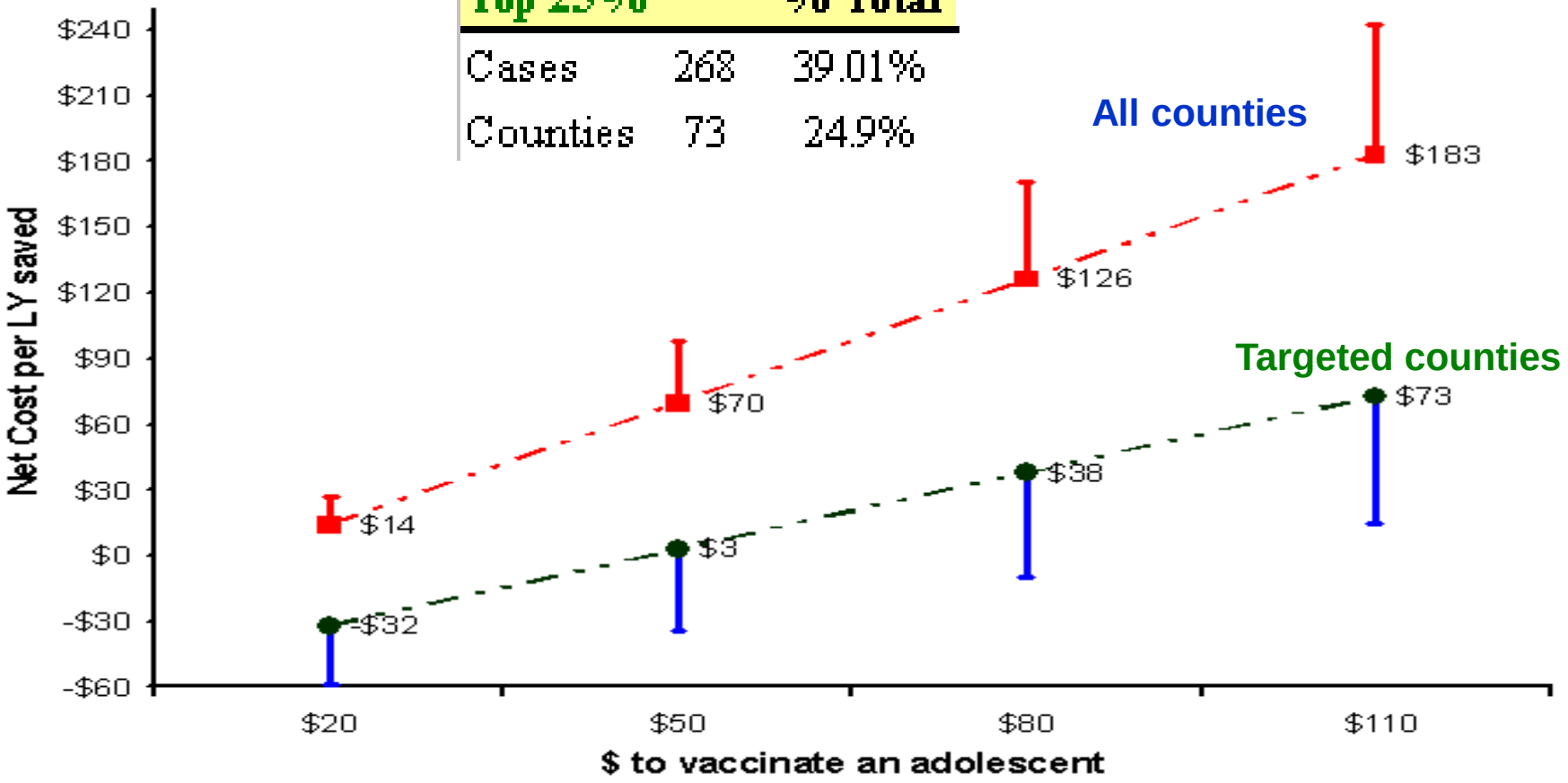
* Assumes 70% vaccine coverage in 11-17 yrs & vaccination cost $83

Net $/LY saved* of Targeting Vaccination

Top 25% Endemic Counties vs. All Counties

Incidence: ~1.57/100K (**Top 25%**)**, ~0.8/100K (**All**)

Top 25% **		% Total
Cases	268	39.01%
Counties	73	24.9%



* Total Net cost, ** Average of 5 years ('98-'02) ABCs data

Assumes 70% of vaccination coverage in 11-17yrs